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USE OF MEMBRANE-FORMING CURING COMPOUNDS ON CONCRETE SURFACES T--ETC(U)
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TECHNICAL REPORT C-68-1

USE OF MEMBRANE-FORMING CURING COMPOUNDS ON CONCRETE SURFACES THAT ARE TO BE PAINTED

Report 2

SUPPLEMENTARY TESTS

by

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October 1976

Report 2 of a Series

Prepared for Office, Chief of Engineers, U. S. Army
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The tests reported herein are a part of an investigation to evaluate membrane forming compounds that can be used for curing concrete surfaces that may thereafter serve as a base for paint. This supplemental phase was conducted to evaluate one curing compound with four paints.

One white pigmented resin-wax based curing compound was tested with four selected paints: (a) an exterior polyvinyl-acetate amulsion paint, (b) an exterior

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and interior styrene-butadiene-acrylate paint, (c) an interior paint, first coat latex, second coat alkyd, and (d) an interior latex paint.

Small concrete panels were molded and coated with the curing compound, then half were painted at one-week age and companion panels were painted at two-months age. Control panels were prepared for comparative purpose by painting directly over the panels after they were cured and dried.

Test and control panels were exposed:

a. Indoors with the face opposite the painted face resting on moist soil.

b. Outdoors exposed to sun and weather (at Jackson, Mississippi).

c. At 100 percent relative humidity and a temperature of 73.4 ± 2°F.

d. At 50 percent relative humidity and a temperature of 73.4 ± 2°F.

The curing compound (compound A) was examined using an infrared spectrophotometer. Results are given in Appendix A.

Inspection after 17-19 months exposure indicated that curing compound A:

a. Can be painted over directly with all of the four paints tested with no adverse effect when the exposure is at 50 percent relative humidity and a temperature of 73.4 ± 2°F.

b. Cannot be used as a base for any of the paints tested when the exposure is outdoors or at high humidity.

c. When the exposure is moist soil indoors, can be used as a base for paint 3 (an exterior styrene-butadiene and styrene-acrylate solvent paint) but cannot be used with the other three paints tested.

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PREFACE

The basic investigation, of which the work reported herein is a part, was authorized by first indorsement from the Office, Chief of Engineers (OCE), dated 7 May 1965, to U. S. Army Engineer Waterways Experiment Station (WES) letter dated 28 April 1965, subject: Project Plan for Investigation of Curing Compounds over Which Paint Can Be Applied Directly. This portion of the work was authorized by representatives of the OCE at the Consultants Conference for Engineering Studies - Concrete in November 1968. The work was done under ES Item 623, "Investigations of Concrete Materials Other Than Cementitious Materials and Aggregates," as project 623.1. The basic work is reported in WES Technical Report C-68-1. This report was prepared for publication using resources from those made available for operation of the Concrete Technology Information Analysis Center in response to requests from the field for state-of-the-art information on this topic. This is CTIAC Report No. 22.

The work was performed during the period January 1970 to October 1971 at the Concrete Laboratory, WES, under the direction of Mr. Bryant Mather and under the supervision of Messrs. J. M. Polatty, R. V. Tye, Jr., R. L. Curry, V. D. Edgerton, W. O. Tynes, Leonard Pepper, and B. J. Houston. This report was prepared by Messrs. B. J. Houston and E. C. Roshore. The report of the infrared examination (Appendix A) was prepared by Mrs. C. F. Derrington.

Directors of WES during the performance of this investigation and preparation of this report were COL Levi A. Brown, CE, BG E. D. Peixotto, CE, COL G. H. Hilt, CE, and COL John L. Cannon, CE. Technical Directors were Messrs. J. B. Tiffany and F. R. Brown.

CONTENTS

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
inches	2.54	centimetres
square feet	0.092903	square metres
cubic feet	0.0283168	cubic metres
cubic yards	0.764555	cubic metres
gallons	3.78533	cubic decimetres
pounds per square inch	0.006894757	megapascals
Fahrenheit degrees	5/9	Celsius degrees or Kelvins*
miles per hour	1.609344	kilometres per hour
bags per cubic yard	55.768	kilograms per cubic metre
square feet per gallon	0.2454425	square metres per cubic decimetre

* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: $C = (5/9)(F - 32)$. To obtain Kelvin (K) readings, use: $(5/9)(F - 32) + 273.16$.

USE OF MEMBRANE-FORMING CURING COMPOUNDS ON CONCRETE SURFACES THAT ARE TO BE PAINTED, SUPPLEMENTARY TESTS

PART I: INTRODUCTION

Background

1. In 1965, the standardized procedures relative to the investigation, planning, design, and construction of concrete structures in the Corps of Engineers Civil Works construction program prohibited the use of membrane-forming curing compounds on concrete surfaces that were later to be painted. It was realized, at that time, that substantial savings could be effected on some construction projects if curing compounds were available that could be painted over directly.

2. A survey was conducted and six curing compounds which were claimed to be satisfactory as a base for paint were located. Seven paints were selected for testing with each curing compound. These paints were those commonly used for painting concrete surfaces.

3. Indoor and outdoor exposure tests were conducted on the curing compound-paint combinations after application to concrete panel surfaces. The results of these tests were reported in July 1968 as Report 1[1] in this series.

Purpose

4. The purpose of this phase of the investigation was to test an additional curing compound to determine if it could be used satisfactorily as a base for four of the paints used in the previous work. The curing compound was one which had been assumed previously to be unsatisfactory as a base for paint.

Scope

5. Concrete panels were made and cured by coating them with the curing compound under test, which was a resin-wax-base white-pigmented compound. After curing by application of the curing compounds, each test panel was painted with one of four paints. The test panels were then exposed to migrating moisture through the face opposite the painted face, to direct moisture, to moderate humidity, and to natural outdoor weathering. Control panels, painted without the curing-compound base, were also exposed for comparative purposes.

PART II: MATERIALS AND TESTS

Materials

Curing compound

6. The curing compound used (compound A) in these tests was a white pigmented resin-wax-based material. Results of infrared examination of this material are given in Appendix A. Compound A conformed to "Specification for Pigmented Membrane-Forming Compounds for Curing Concrete," CRD-C 300.[2]

Paints

7. The following paints were tested with the curing compound:

   a. Paint 2, exterior, polyvinyl acetate emulsion,[3] two coats, conforming to Federal Specification TT-P-0055.[3]

   b. Paint 3, exterior, styrene-butadiene and styrene-acrylate solvent, two coats, Type II, conforming to Federal Specification TT-P-0097.[4]

   c. Paint 6, one coat of paint conforming to Federal Specification TT-P-0029d[5] (paint 7) followed by one coat of interior flat alkyd[6] paint conforming to Federal Specification TT-P-30b.[6]

   d. Paint 7, interior, latex base paint,[5] two coats, conforming to Federal Specification TT-P-0029d.[5]

8. The paints selected were those that are frequently used in painting concrete and included both interior and exterior paints. Painting was done as recommended for that particular paint for painting.

Tests

Concrete mixture and casting of panels

9. One 12-cu ft batch of approximately 2500-psi compressive strength concrete, containing five bags per cu yd of Type II portland cement from a source in Alabama, 3/4-in.-maximum-size limestone coarse and fine aggregate from a source in Tennessee, and having a slump of 2-1/2 $\pm$ 1/2 in., and an air content of 5-1/2 $\pm$ 1/2 percent was made. From this batch of

concrete, 48 small panels, 10 by 10 by 2-1/2 in., were cast and stripped from the molds after 24 hr moist curing. After stripping, the bottom formed faces of 32 of the panels were coated with the curing compound by spray-applying the compound at the rate of 200 sq ft per gal, and the 32 panels were then allowed to air-dry in the laboratory. The coated faces of half (16) of the coated panels were painted at five-days age, and those of the other half (16) were painted at approximately two-months age. The panels that were coated with a curing compound and then painted are referred to as "test panels." The remaining 16 panels were used as "control panels." These control panels were moist-cured for five days without curing compound, then air-dried until one-month age at 50 percent relative humidity, and painted for comparative purposes.

Exposure of panels

10. Twelve panels (eight test panels and four control panels) were exposed under each of the following conditions:

a. Indoors in a horizontal position with the face opposite the painted face resting on moist soil (see Fig. 1).

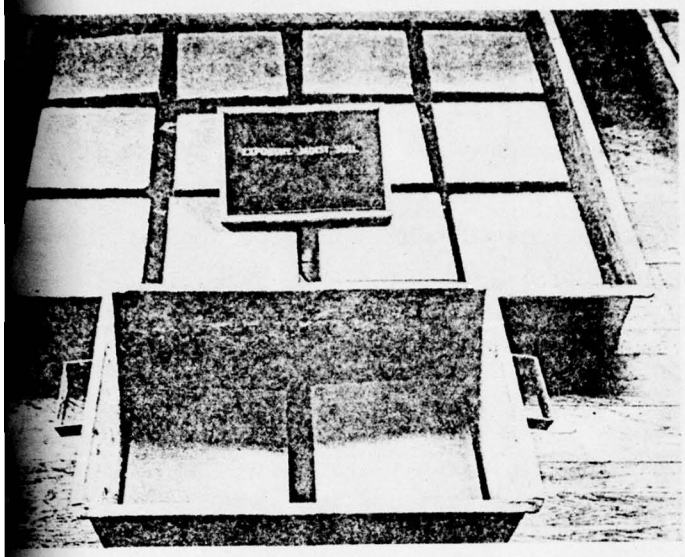
b. In the field (at Jackson, Mississippi) exposed to sun and weather (see Fig. 2).

c. At 100 percent relative humidity and a temperature of 73.4 $\pm$ 2°F (see Fig. 3).

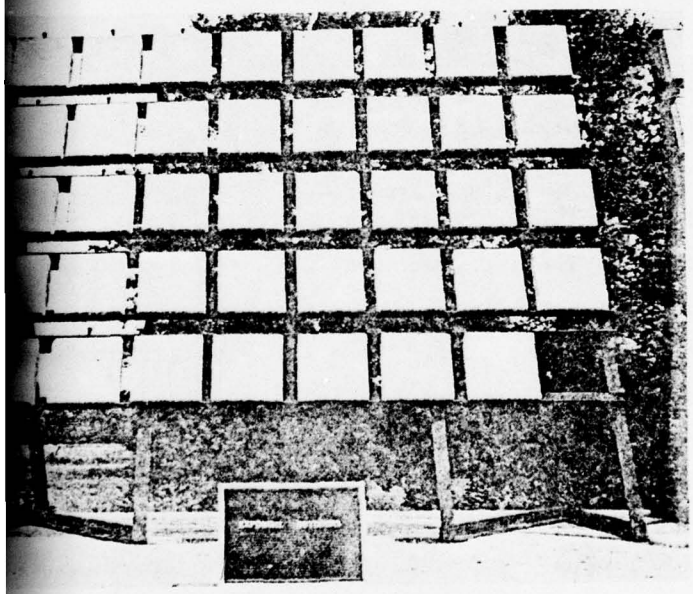
d. At 50 percent relative humidity and a temperature of 73.4 $\pm$ 2°F (see Fig. 4).

11. Table 1 lists the panels and gives their individual treatment and disposition. The two ages (one week and two months) were used for painting since on actual structures the age of the curing membrane at the time of overpainting may range from one week to many weeks, since painting is often delayed until reasonably large areas are available. Prolonged aging of some curing membranes might possibly result in their partial deterioration prior to painting, with a resulting adverse effect on paint performance.

12. The control panels (as stated in para 9) were moist-cured for five days after casting, then air-dried in a 50 percent humidity room until one-month age before painting. This was done because manufacturers' recommendations for all types of paints, except possibly water-cement



1. Painted specimens exposed with the face
posite the painted face in moist soil



re 2. Outdoor exposure station for exposing
painted concrete panels

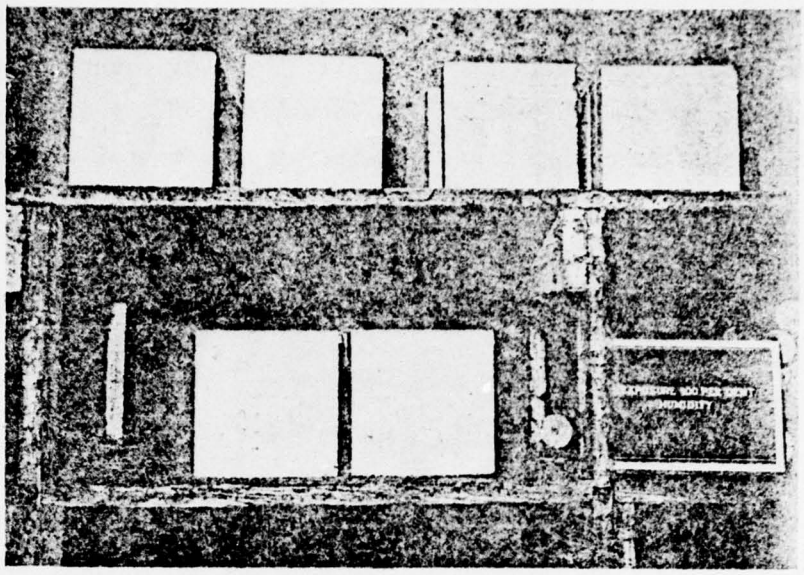


Figure 3. Painted specimens exposed to 100 percent relative humidity

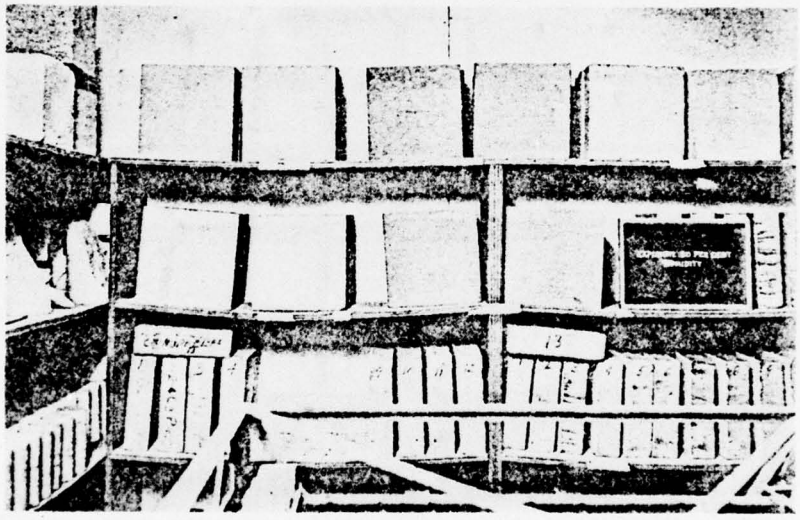


Figure 4. Painted specimens exposed at 50 percent relative humidity

paints, require a cured, dry concrete surface for painting. The high concentration of soluble salts and alkalies on a new concrete surface might cause disturbances within the applied layer of paint during the drying process, precluding proper film formation, or the alkalies might damage the film after it has dried. Painting the control panels after drying for three to four weeks at 50 percent relative humidity should represent ideal conditions for painting directly over concrete, and ensure a valid comparison with the test results.

13. In Corps of Engineers construction, upward facing horizontal concrete surfaces are generally left unpainted. For this reason the formed surface of each test panel was coated and painted instead of the finished surface. The vertical faces and undersides of horizontals, which are formed surfaces, are often painted, while painting of concrete floor surfaces is discouraged except in isolated instances.

14. The concrete panels remained exposed under the four conditions for a period of 17 to 19 months with periodic inspections conducted. A final inspection (after 17 to 19 months) was made in September 1971 and the final condition of the panels is given in Table 2.

PART III: RESULTS AND CONCLUSIONS

Results

15. The condition (see Table 2) of the panels after 17 to 19 months exposure at the exposure locations was evaluated, and a grading system was developed for comparison of the test panels with their control panels. This grading system is as follows:

Grading

1	Much worse than control
2	Worse than control
3	Slightly worse than control
4	Good as control
5	Slightly better than control
6	Better than control
7	Much better than control

16. Comparisons can be made using this grading system by reference to Tables 3 and 4.

Outdoor exposure

17. None of the test panels withstood outdoor weathering as well as the control panels, and only the control panels with paints 2 and 6 performed satisfactorily. All of the test panels fared badly whether painted at one week or two months.

Moist soil exposure

18. Three of the four control panels performed satisfactorily; the control panel with paint 6 showed some distress. The test panels painted with paint 3 withstood the exposure as well as the paint 3 control panel. Test panels representing paints 2, 6, and 7, whether painted at one week or two months, were in worse condition than their control panels.

100 percent humidity exposure

19. Test panels painted with paint 6 withstood this exposure better than the control panel, but since the control panel was severely affected by the exposure, the paint 6 test panels are still unsatisfactory. Control panels with paints 2 and 3 performed unsatisfactorily in this exposure as did the test panels representing paints 2, 3, and 7 at both ages.

50 Percent humidity exposure

20. There were no discernible differences between any of the test panels and comparable control panels exposed at 50 percent humidity and no deterioration was noted on any of the panels.

Conclusions

21. It appears that curing compound A can be painted over directly with all four paints tested with no adverse effect when the exposure is indoors at a temperature of 73.4 $\pm$ 2°F and a relative humidity of 50 percent.

22. Curing compound A cannot be used as a base for any of the four paints tested when the exposure is to be outdoors or under high humidity conditions.

23. Curing compound A cannot be used as a base for paints 2, 6, or 7 in an exposure equivalent to the moist-soil exposure used in this investigation.

24. It appears that for a moist-soil indoor exposure, curing compound A can be used as a base for paint 3 (exterior, styrene-butadiene, and styrene-acrylate solvent paint).

25. In summary, curing compound A cannot be used as a base for paints except under very special conditions (with certain paints and under certain specific exposure conditions).

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2. U. S. Army Engineer Waterways Experiment Station, CE, Handbook for Concrete and Cement, April 1949 (with quarterly supplements), Vicksburg, MS.

3. U. S. General Services Administration, "Paint, Polyvinyl Acetate Emulsion, Exterior," Federal Specification TT-P-0055, 21 May 1958 (revised 27 April 1965), Government Printing Office, Washington, DC.

4. _____, "Paint, Styrene-Butadiene and Styrene-Acrylate Solvent Type (For Exterior Masonry)," Federal Specification TT-P-0097, 9 Mar 1964 (revised 6 Apr 1965), Government Printing Office, Washington, DC.

5. _____, "Paint, Latex-Base, Interior, Flat, White and Tints," Federal Specification TT-P-0029d, Aug 1964 (revised 16 Aug 1967), Government Printing Office, Washington, DC.

6. _____, "Paint, Alkyd, Odorless, Interior, Flat, White and Tints," Federal Specification TT-P-30b, Sep 1959 (revised 27 June 1967), Government Printing Office, Washington, DC.

Table 1

Treatment and Disposition of Concrete Panels

Panel No.	Curing Compound Used	Paint Used	Remarks	Exposure
1	Compound A	No. 2		Outdoors
2	"	"		Moist soil
3	"	"		100% RH
4	"	"		50% RH
5	"	No. 3		Outdoors
6	"	"	Moist-cured in mold 24 hr, stripped, curing compound applied, cured in air until 5 days old, painted, then exposed at one week age.	Moist soil
7	"	"		100% RH
8	"	"		50% RH
9	"	No. 6		Outdoors
10	"	"		Moist soil
11	"	"		100% RH
12	"	"		50% RH
13	"	No. 7		Outdoors
14	"	"		Moist soil
15	"	"		100% RH
16	"	"		50% RH
17	None (control)	No. 2		Outdoors
18	"	"		Moist soil
19	"	"		100% RH
20	"	"		50% RH
21	"	No. 3	Moist-cured for 5 days, dried at 50% RH until one month old, then painted and exposed.	Outdoors
22	"	"		Moist soil
23	"	"		100% RH
24	"	"		50% RH
25	"	No. 6		Outdoors
26	"	"		Moist soil
27	"	"		100% RH
28	"	"		50% RH

(Continued)

Table 1 (Concluded)

Panel No.	Curing Compound Used	Paint Used	Remarks	Exposure
29	None (control)	No. 7		Outdoors
30	"	"	Moist-cured for 5 days, dried at 50% RH until one month old, then painted and exposed.	Moist soil
31	"	"		100% RH
32	"	"		50% RH
33	Compound A	No. 2		Outdoors
34	"	"		Moist soil
35	"	"		100% RH
36	"	"		50% RH
37	"	No. 3		Outdoors
38	"	"	Moist-cured in mold for 24 hr, stripped, curing compound applied, cured in air until 2 months old, painted, then exposed.	Moist soil
39	"	"		100% RH
40	"	"		50% RH
41	"	No. 6		Outdoors
42	"	"		Moist soil
43	"	"		100% RH
44	"	"		50% RH
45	"	No. 7		Outdoors
46	"	"		Moist soil
47	"	"		100% RH
48	"	"		50% RH

Table 2

Condition of Painted Panels After 17-19 Months Exposure

Curing Compound	Age When Exposed	Paint 2, Exterior Polyvinyl Acetate	Paint 3, Exterior Styrene-Butadiene & Styrene-Acrylate	Paint 6, 1st Coat Interior Latex, 2nd Coat Alkyd	Paint 7, Interior Latex
			Outdoor Exposure		
Control	1-mo	Okay	Light cracking	Okay	Some peeling
Compound A	1-wk	Peeling badly	Heavy cracking	Moderate cracking	Peeling badly
Compound A	2-mo	Some peeling	Moderate cracking	Light cracking	Peeling badly
			Moist Soil Exposure		
Control	1-mo	Okay	Okay	One crack	Okay
Compound A	1-wk	Flaking	Okay	Spotted	Fading
Compound A	2-mo	Heavy flaking	Okay	Moderately spotted	Flaking
			100 Percent Humidity Exposure		
Control	1-mo	Paint soft	Paint soft--badly blistered	Paint soft--spotted	Okay
Compound A	1-wk	Paint soft--blistered	Paint soft--badly blistered	Paint soft--two spots	Blistered
Compound A	2-mo	Paint soft--blistered	Paint soft--badly blistered	Paint soft--one spot	Badly blistered
			50 Percent Humidity Exposure		
Control	1-mo	Okay	Okay	Okay	Okay
Compound A	1-wk	Okay	Okay	Okay	Okay
Compound A	2-mo	Okay	Okay	Okay	Okay

Table 3

Comparison of Test Panels (Curing Compound Painted Over)

with Control Panels (Painted Directly Over Concrete)

		With Curing Compound A						
		Paint Numbers*						
Exposure Conditions	Age when Exposed	Much Better than Control	Better than Control	Slightly Better than Control	Good as Control	Slightly Worse than Control	Worse than Control	Much Worse than Control
Outdoors	1-wk	--	--	--	--	--	7	2,3,6
	2-mo	--	--	--	--	--	2,3,6,7	--
Moist soil	1-wk	--	--	--	3	7,6	2	--
	2-mo	--	--	--	3	--	6,7	2
100% humidity	1-wk	--	--	6	3	--	2,7	--
	2-mo	--	6	--	3	--	2	7
50% humidity	1-wk	--	--	--	2,3,6,7	--	--	--
	2-mo	--	--	--	2,3,6,7	--	--	--

* Identification of paints is shown in the Key.

Table 4

Grading of Test Panels Compared to

Control Panels with Curing Compound A

Paint	Age When Exposed	Grading for Type of Exposure Shown			
		Outdoors	Moist Soil	100% Humidity	50% Humidity
2	1 week	1	2	2	4
3	1 week	1	4	4	4
6	1 week	1	3	5	4
7	1 week	2	3	2	4
2	2 months	2	1	2	4
3	2 months	2	4	4	4
6	2 months	2	2	6	4
7	2 months	2	2	1	4

Grading System

1 - Much worse than control.

2 - Worse than control.

3 - Slightly worse than control.

4 - Good as control.

5 - Slightly better than control.

6 - Better than control.

7 - Much better than control.

APPENDIX A: INFRARED EXAMINATION OF CURING COMPOUND

Description of Examination

1. Infrared spectra were obtained on compound A using a Beckman IR-8 spectrophotometer in the region 2.5 to 16 microns. After centrifuging the compound, three samples were prepared for IR analysis as follows:

a. The top centrifuged portion (as-received) was gently pressed between sodium chloride crystals and then tested (spectrum obtained is shown as Plate A1).

b. A sample of the top centrifuged portion was gently heated on a NaCl crystal at less than 50°C until the apparent evaporation of the solvent, leaving a slightly tacky residue (dried film) which was then tested (spectrum obtained is shown as Plate A2).

c. The settled pigment in the bottom of the centrifuge tube was spread evenly over a NaCl crystal and allowed to evaporate at less than 50°C. The portion remaining was then tested (the spectrum obtained is shown as Plate A3).

Results

2. The material is identified as being a carboxylated hydrocarbon. The strongest absorptions of the "as-received" top portion (pigment not present) were noted in the 3.4-3.5 region, indicating aliphatic C-H vibrations. The presence of both methyl and methylene groups is evident by the strong sharp band at 6.9, whereas the medium sharp band at 7.3 indicates only methyl deformation vibrations. The medium strong band at 5.9 is characteristic of C=O vibrations found in carboxylic acids, while the band at 6.3-6.5 is ascribed to C-O stretching vibrations and is typical of carboxylate absorptions found in resinous materials. Additional weaker bands are noted in the 12-15 region and are due primarily to the solvent in compound, indicating the presence of some cyclic and aromatic groups. A comparison of the dried film spectrum with the "as-received" spectrum indicates the solvent to be primarily long-chain aliphatic hydrocarbons of the naphtha type, with fewer aromatic groups.

Also the doublet in the region 13.8-14.0 of the dried film indicates the presence of ethylene groups in the crystalline state. The spectrum of the pigment indicates that it is composed primarily of calcite ($CaCO_3$), $CaSO_4$, and TiO_2. The calcite absorptions are evident at 7, 11.45, and 14.1, whereas the $CaSO_4$ absorptions are noted at 8.7-9.0 and 14.9.

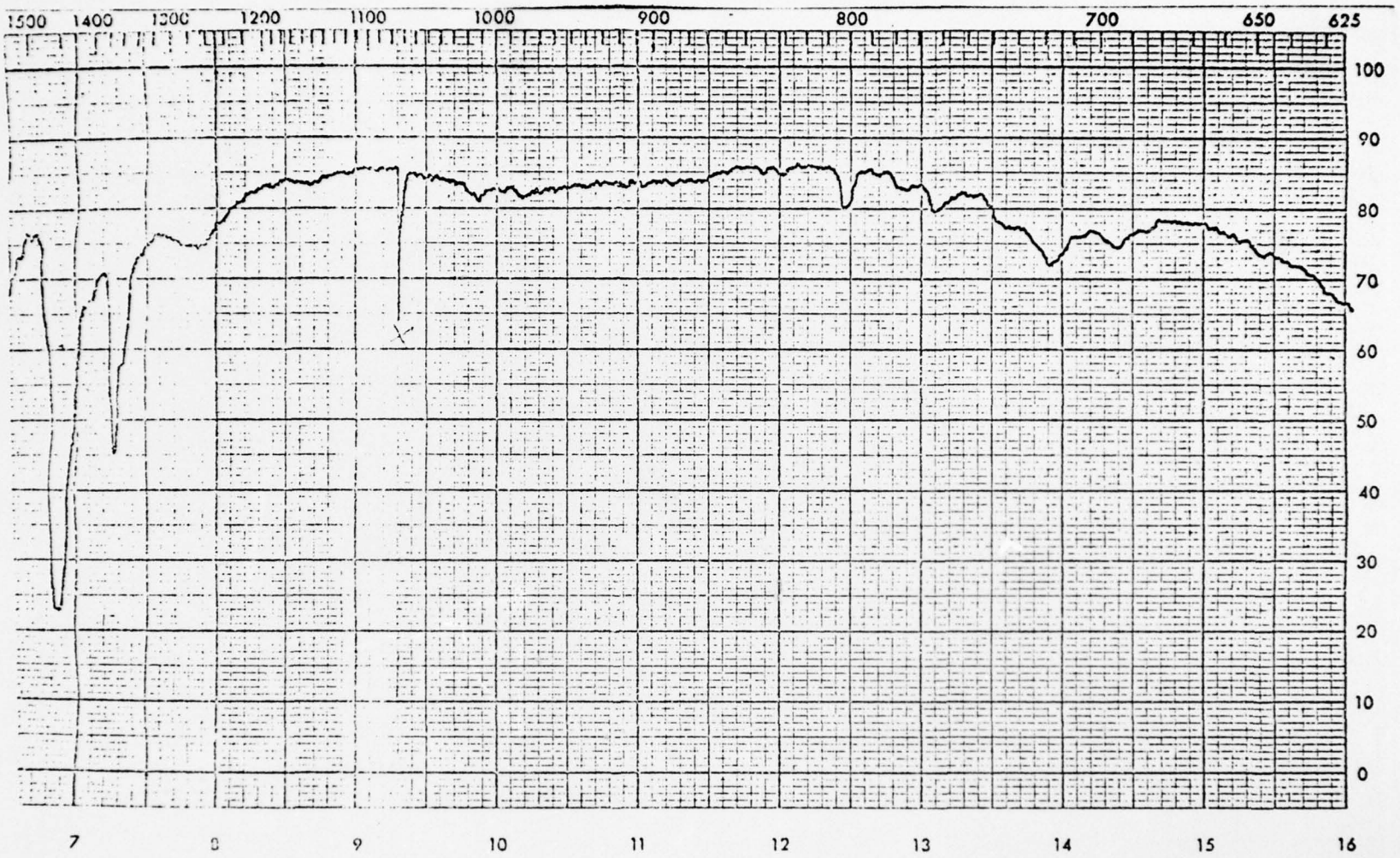


Plate A1. Infrared spectrum curing compound A (as-received)

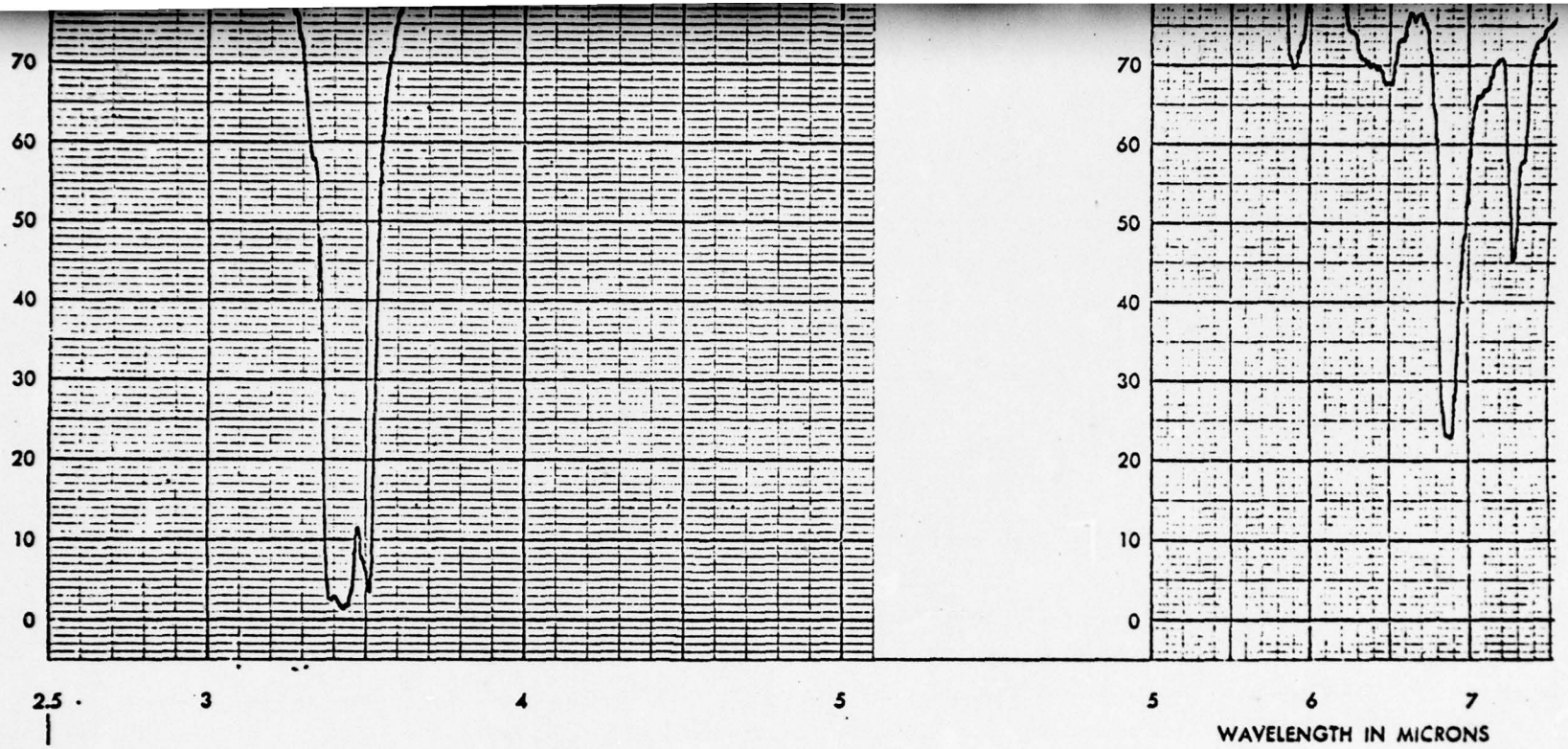


Plate A1. (Concluded)

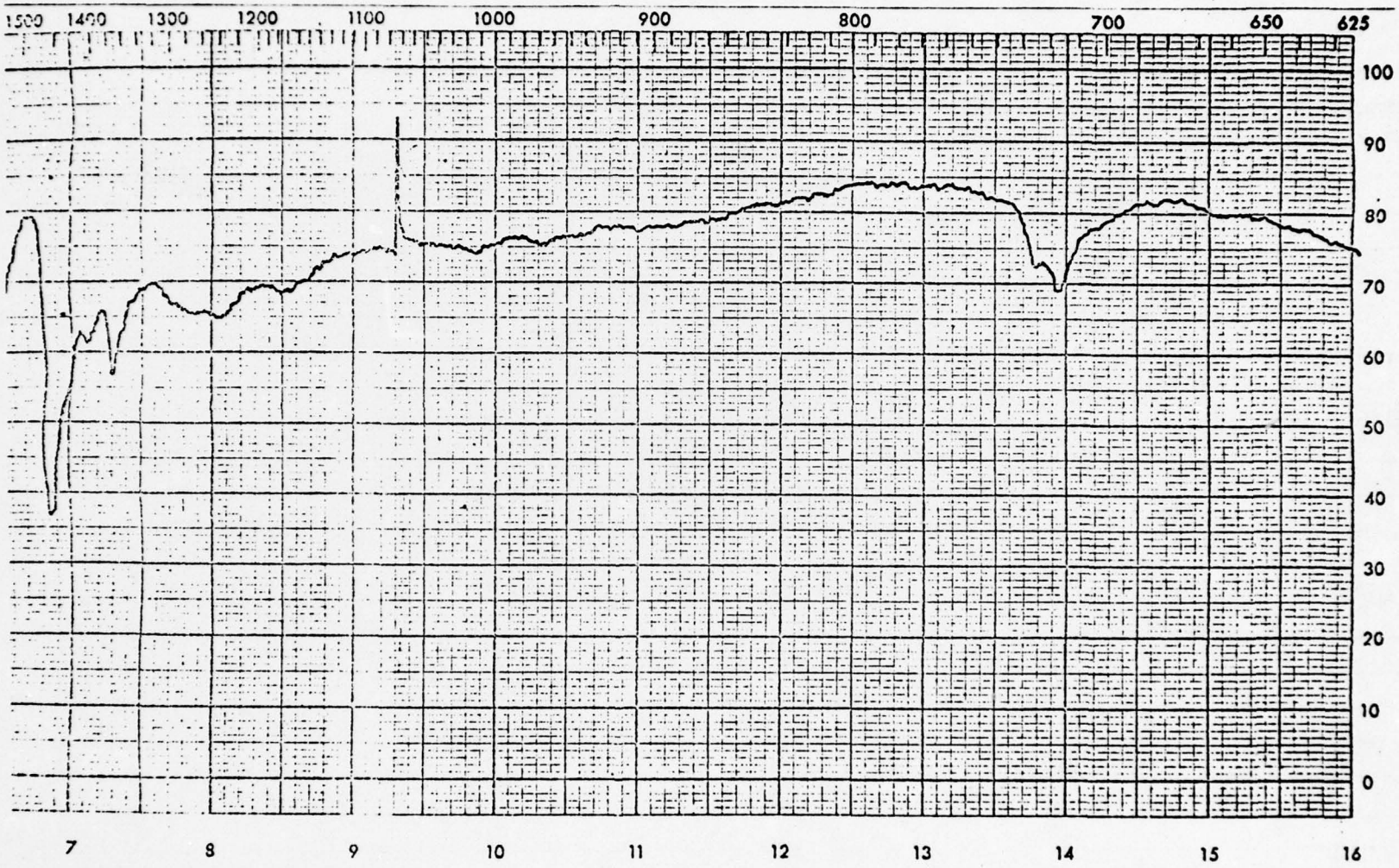
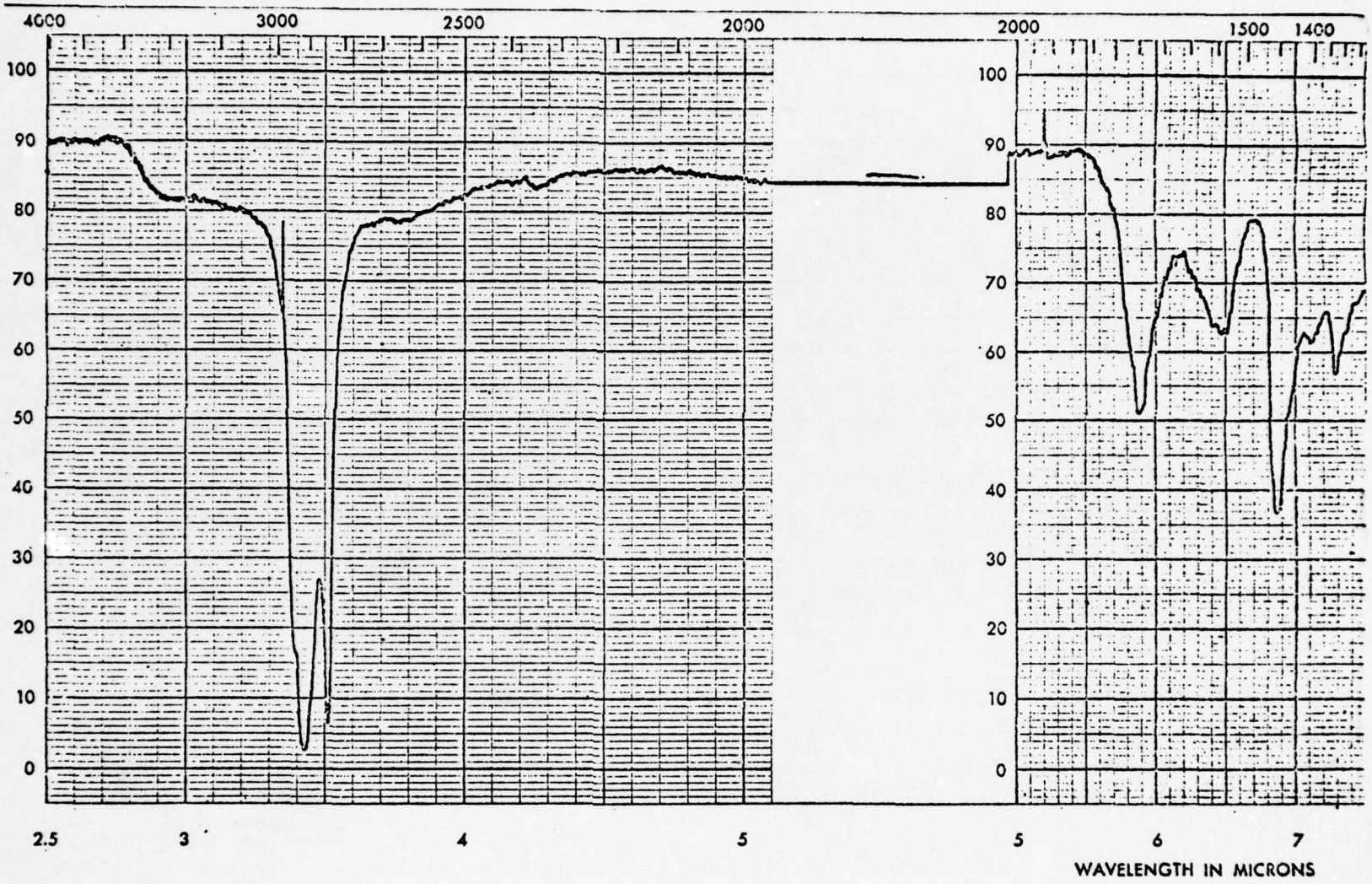


Plate A2. Infrared spectrum curing compound A (dried film)



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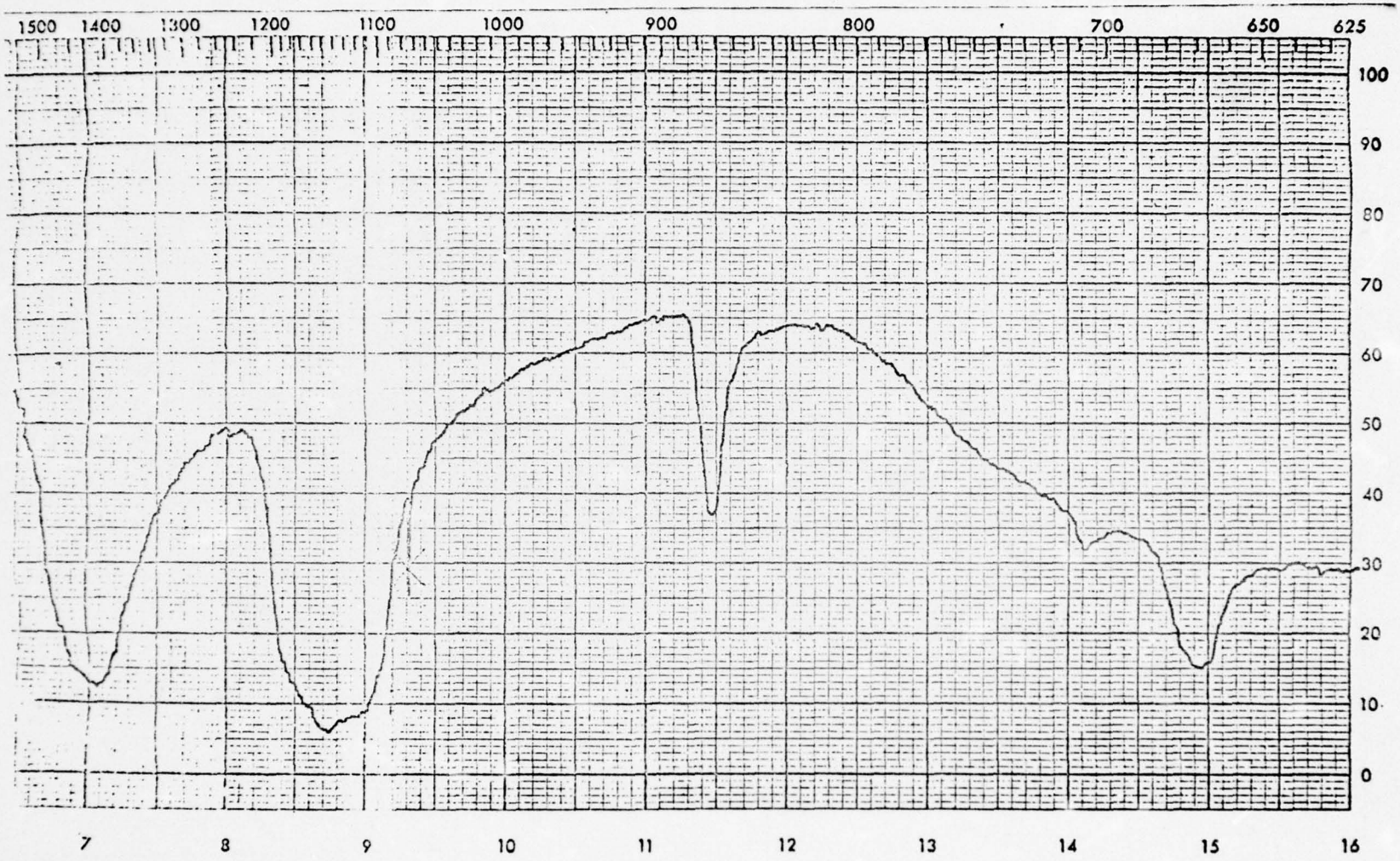

Plate A3. Infrared spectrum curing compound A (pigment)

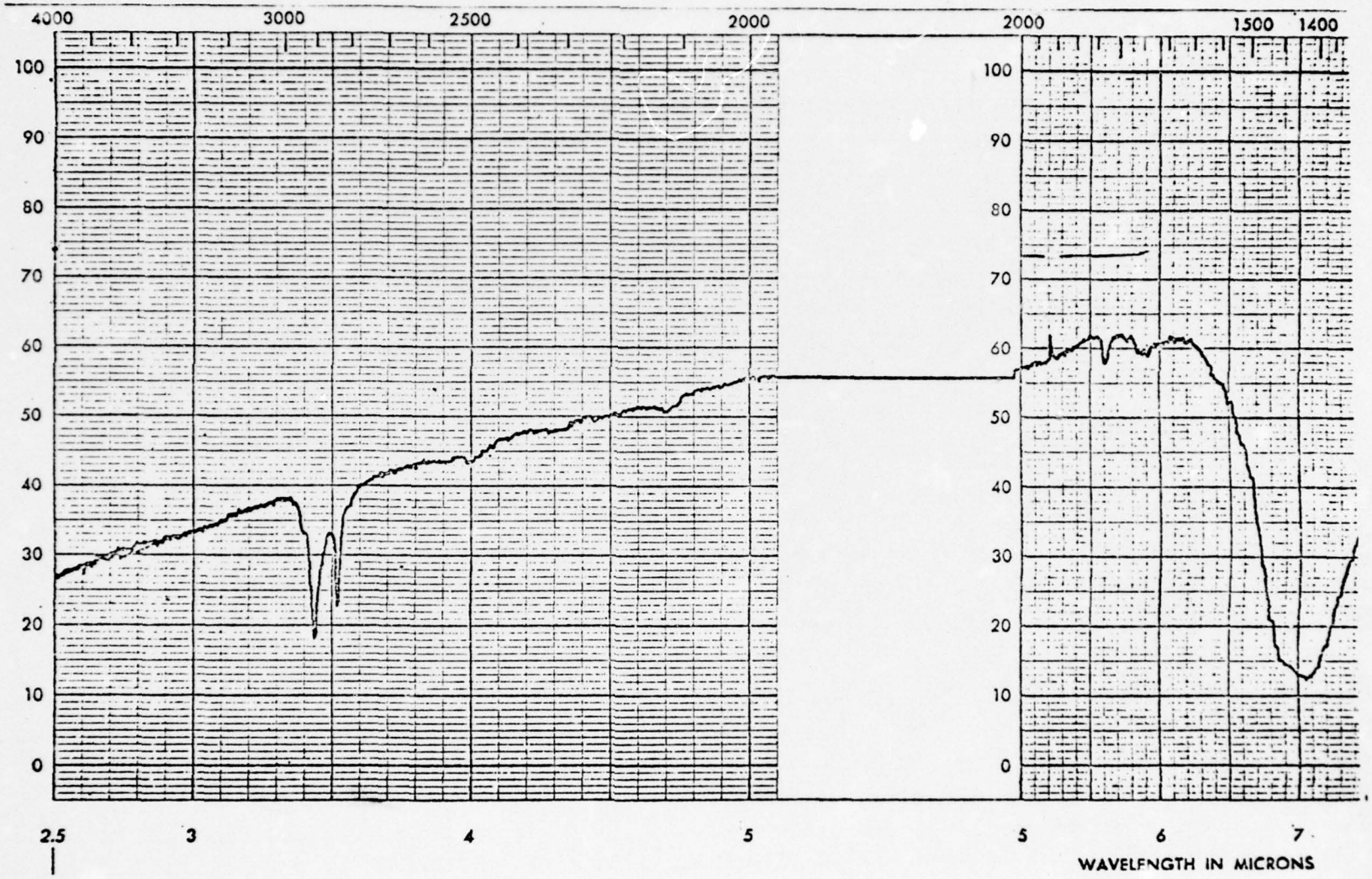

Plate A3. (Concluded)

In accordance with ER 70-2-3, paragraph 6c(1)(b), dated 15 February 1973, a facsimile catalog card in Library of Congress format is reproduced below.

Houston, Billy Joe

Use of membrane-forming curing compounds on concrete surfaces that are to be painted; Report 2: Supplementary tests, by Bill J. Houston [and] Edwin C. Roshore. Vicksburg, U. S. Army Engineer Waterways Experiment Station, 1976.

1 v. (various pagings) illus. 27 cm. (U. S. Waterways Experiment Station. Technical report C-68-1, Report 2)

Prepared for Office, Chief of Engineers, U. S. Army, Washington, D. C.

Includes bibliography.

1. Curing compounds. 2. Paint. 3. Paint over. I. Roshore, Edwin C., joint author. II. U. S. Army. Corps of Engineers. (Series: U. S. Waterways Experiment Station, Vicksburg, Miss. Technical report C-68-1, Report 2)

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